DC- The Power to Change the World

From Data Centers to Whole Buildings

Brian T. Patterson - Chairman
Governing Member, EMerge Alliance
General Manager, Armstrong World Industries

Microgrid RD&D Workshop
October 3, 2012

The EMerge Vision:

DOING FOR POWER WHAT THE INTERNET DID FOR INFORMATION NETWORKING

The Current Reality

PROBLEM: Mismatched AC and DC Power Distribution Requirements

ENERGY SOURCES – MIXED AC & DC

AC/DC Site Generation

DC Campus Fuel Cells

DC Power Storage

DC Photovoltaic

DC Wind Power

AC Line Power

ELECTRIC DEVICES – TYPICALLY DC

Electronic Lighting

HVAC Actuators Sensors & Controls

Electric Vehicles

AV/IT Devices

Data & Telecom Centers

Security & Safety

"80 percent of power used in commercial buildings must go through some form of power electronics so it can be converted to DC," - the Center of Power Electronics Systems at Virginia Tech.

RESULT: Opportunity to Simplify- Improve Efficiency, Quality, Reliability, Control, Safety

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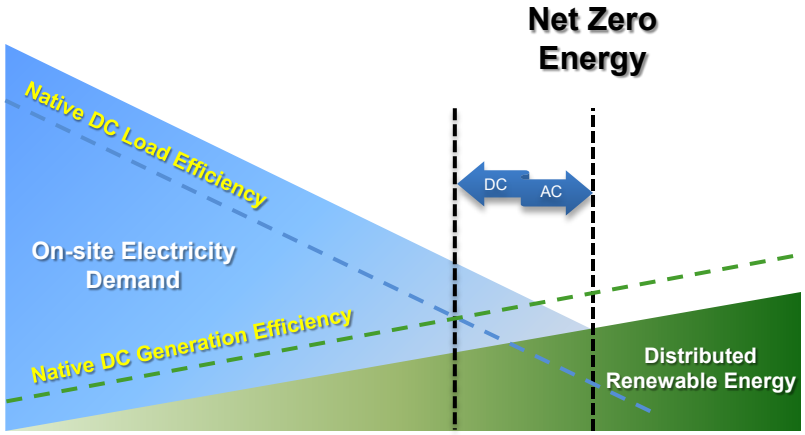
Net Zero Energy Building Model

Buildings that produce as much energy as they consume

1. **Integrated design** and operations planning
2. **Site renewable** strategies get optimized using dc
3. **Energy Storage** in dc allow Grid independence
4. **System Intelligence** control, monitor, verify

U.S. DEPARTMENT OF ENERGY

ZERO ENERGY COMMERCIAL BUILDINGS CONSORTIUM



"DC power would fundamentally change the way power is distributed in commercial buildings…"

2012: **Begin DC Microgrid Demonstrations**

2030: **All new commercial buildings**

2040: **50% of commercial building stock**

2050: **All commercial buildings**

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From Smart Grid to Microgrids

The Need to Balance the Renewable Power Equation

Generation

Transmission

Distribution

Smart Grid

Microgrid

Smart Meters

Smart Buildings

Smart Homes

Local Generation

Local Energy Storage

Why Microgrids?

- Increase renewable energy availability
- Improve, reliability & independence / security
- Improve availability in underserved markets
- Create open environment for energy innovation

Slide Courtesy of Intel Research Labs

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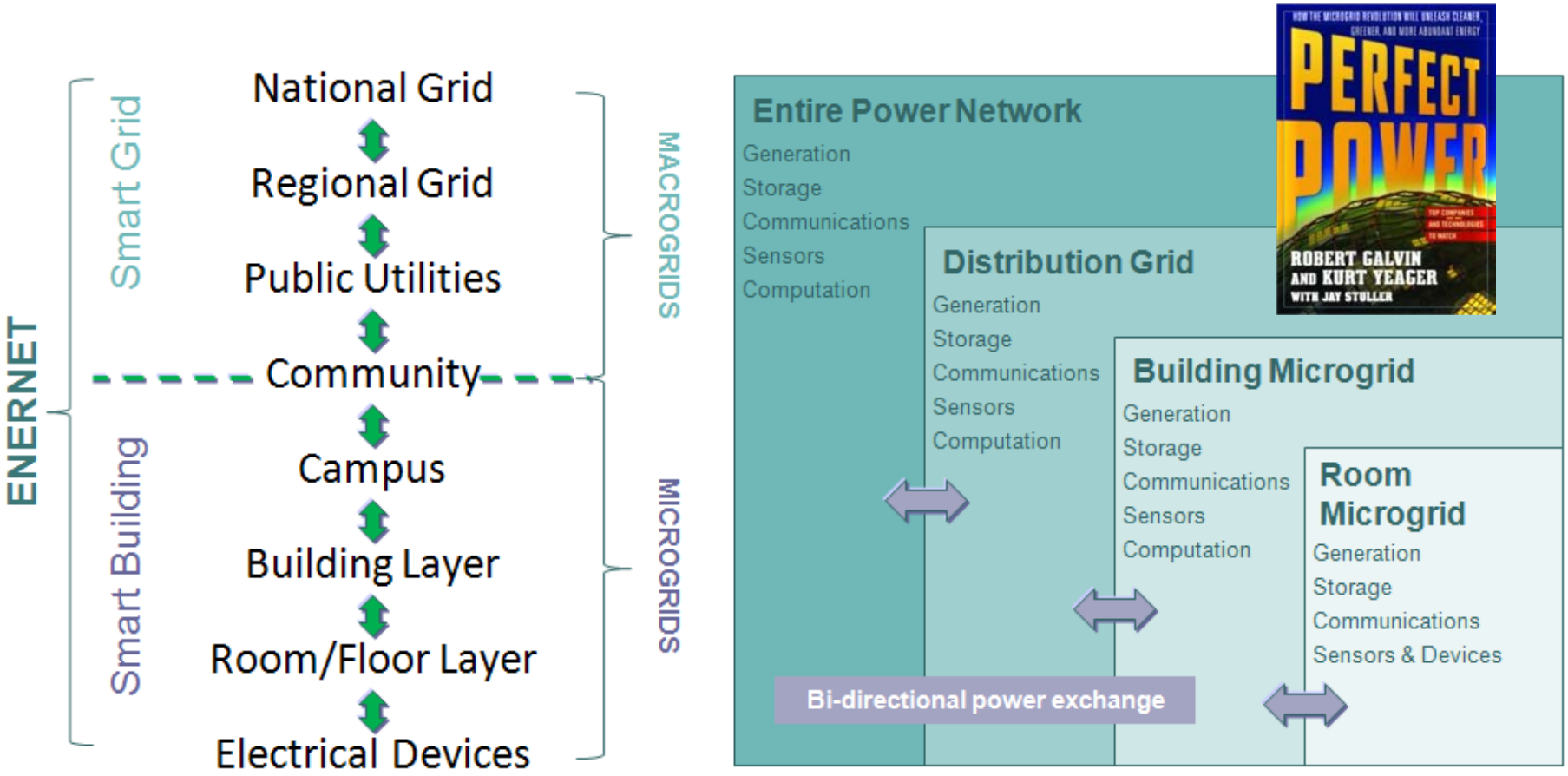
Smart Grid to Smart Buildings:

Layered Microgrids at the Core of the New Energy Network



En•er•net: noun \en-ər-net\ : the Internet of powered things Bob Metcalfe

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The Desired State

A simplified AC/DC hybrid coupled power network

ENERGY SOURCES

AC/DC Site Generation

DC Photovoltaic

DC Campus Fuel Cells

DC Wind Power

DC Power Storage

AC Line Power

Coupled AC/DC Power Sources

▲

DC Power Distribution Management

▼

Intelligent Wired & Wireless Controls

ELECTRO-ACTIVE DEVICES

Electronic Lighting

AV/IT Devices

HVAC Actuators Sensors & Controls

Data & Telecom Centers

Electric Vehicles

Security & Safety

OPPORTUNITY:

More flexibility, less energy, less capital, safer & more reliable

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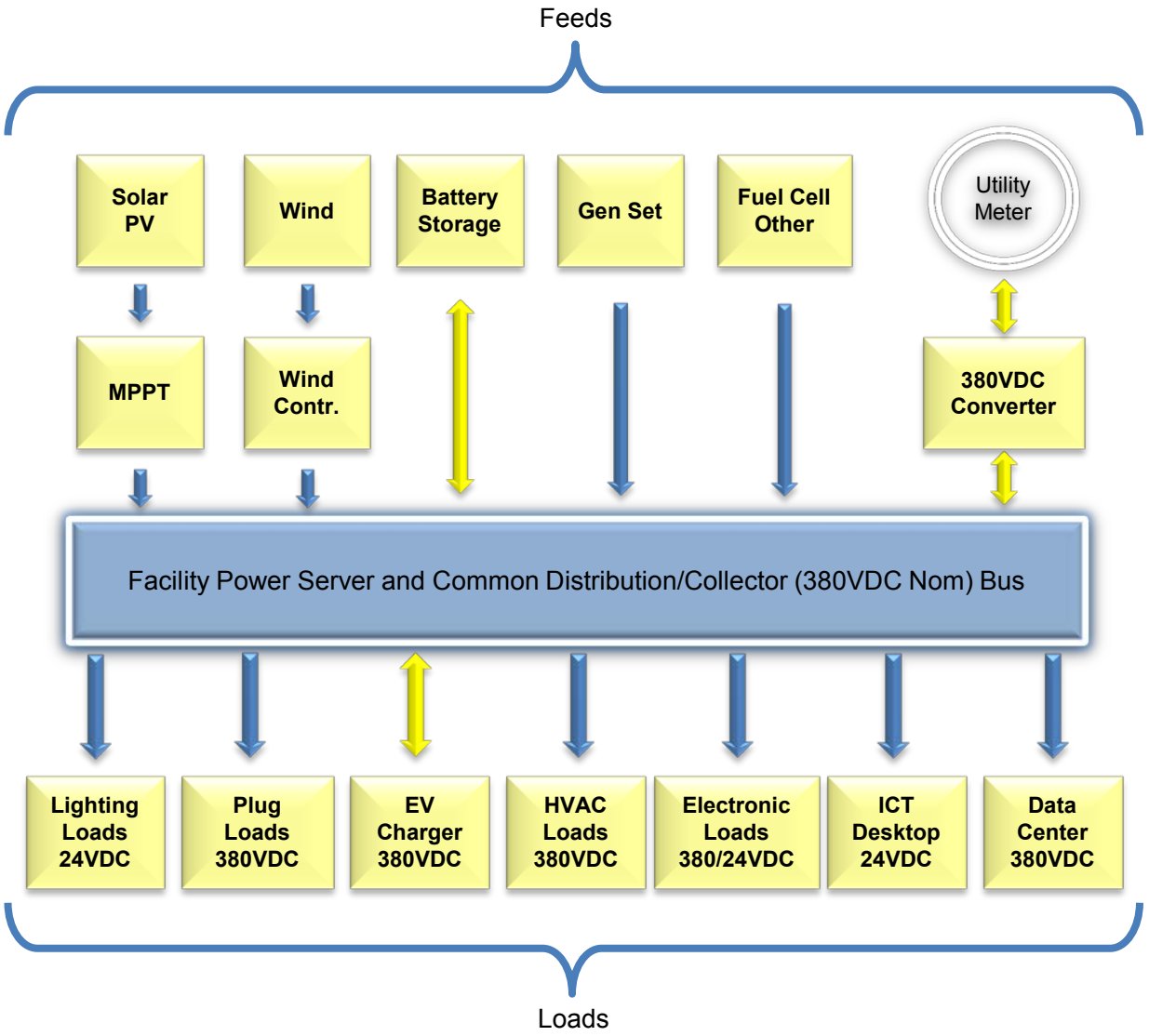
Zero Net Energy Buildings (ZEB)

DC Microgrid with Renewable & Alternate Distributed Generation

Slide Courtesy of EMERSON Network Power



DC Microgrid may include :

- Various AC and DC loads: fixed & plug and play loads
- Dispatchable generation: fuel cell or bio-fuel turbine.
- Non-dispatchable sources: solar PV and wind turbines.
- Energy storage, such as ultra-capacitors or batteries.
- Common Distribution – Collector Bus
- Management & Demand Response (DR) capability
- Ride-thru & Off-grid operation capability (islandable)

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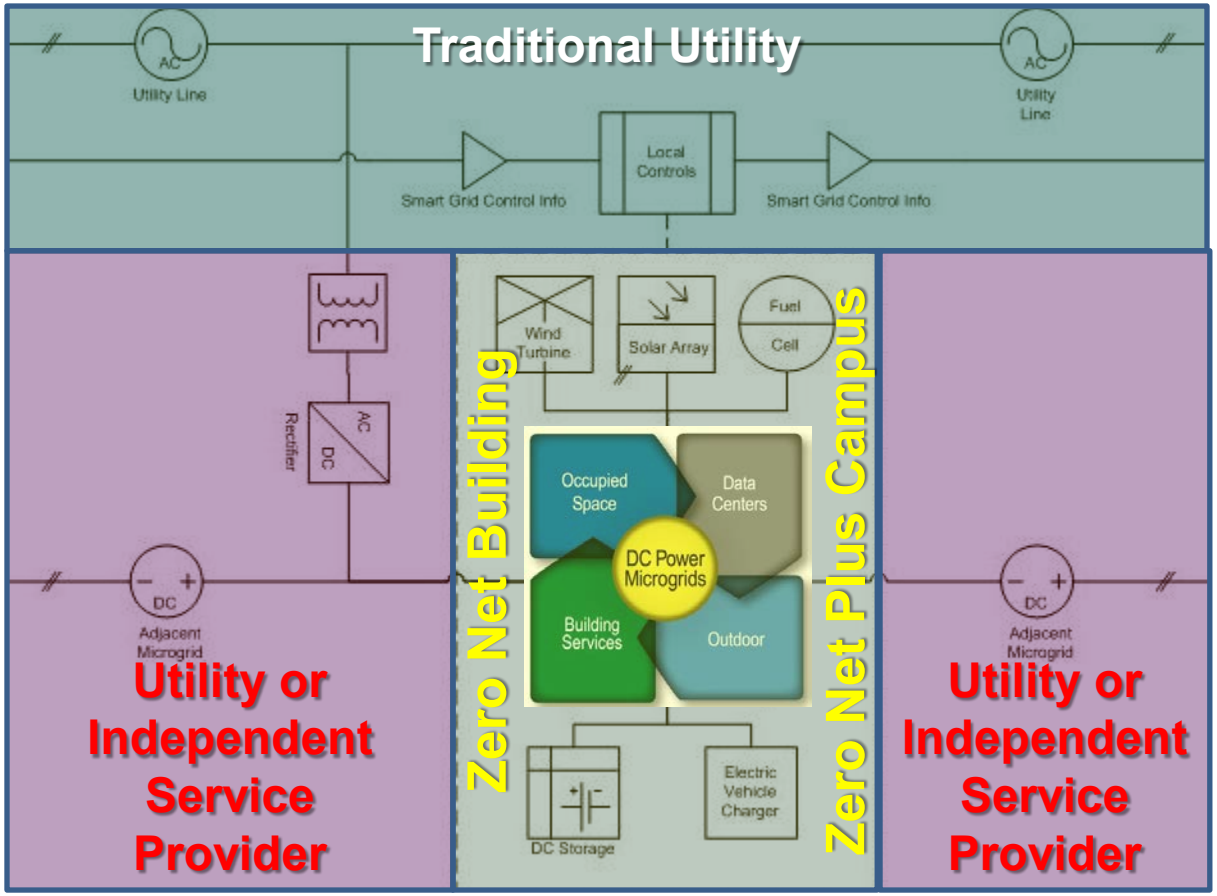
Zero Energy Buildings (ZEB)

A ZEB driven network will look much like the Internet

DC MICROGRID MODEL



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DC

The Power to Change the World

Enernet: Doing for power what the Internet did for information networking

EMerge® ALLIANCE

DC-The Power to Change Buildings

What is the EMerge Alliance?

- Not-for-profit 501c -Part 6
- Open application standards - DC platform
- Eco-system development and promotion
- 100+ Member organizations and growing!

Who is the EMerge Alliance?

- Architects, Engineers
- Contractors/Builders/ Integrators
- Manufacturers - Service Providers
- Building Owners – Facility Managers
- National & Independent Labs
- Academic Institutions
- Codes & Standards Groups

What is an EMerge Standard?

- Commercial Applications Standards
- Subordinate to safety, equipment standards
- Physical, electrical, operational interfaces
- Application definition - listing requirements of other standards (incl. IEC)

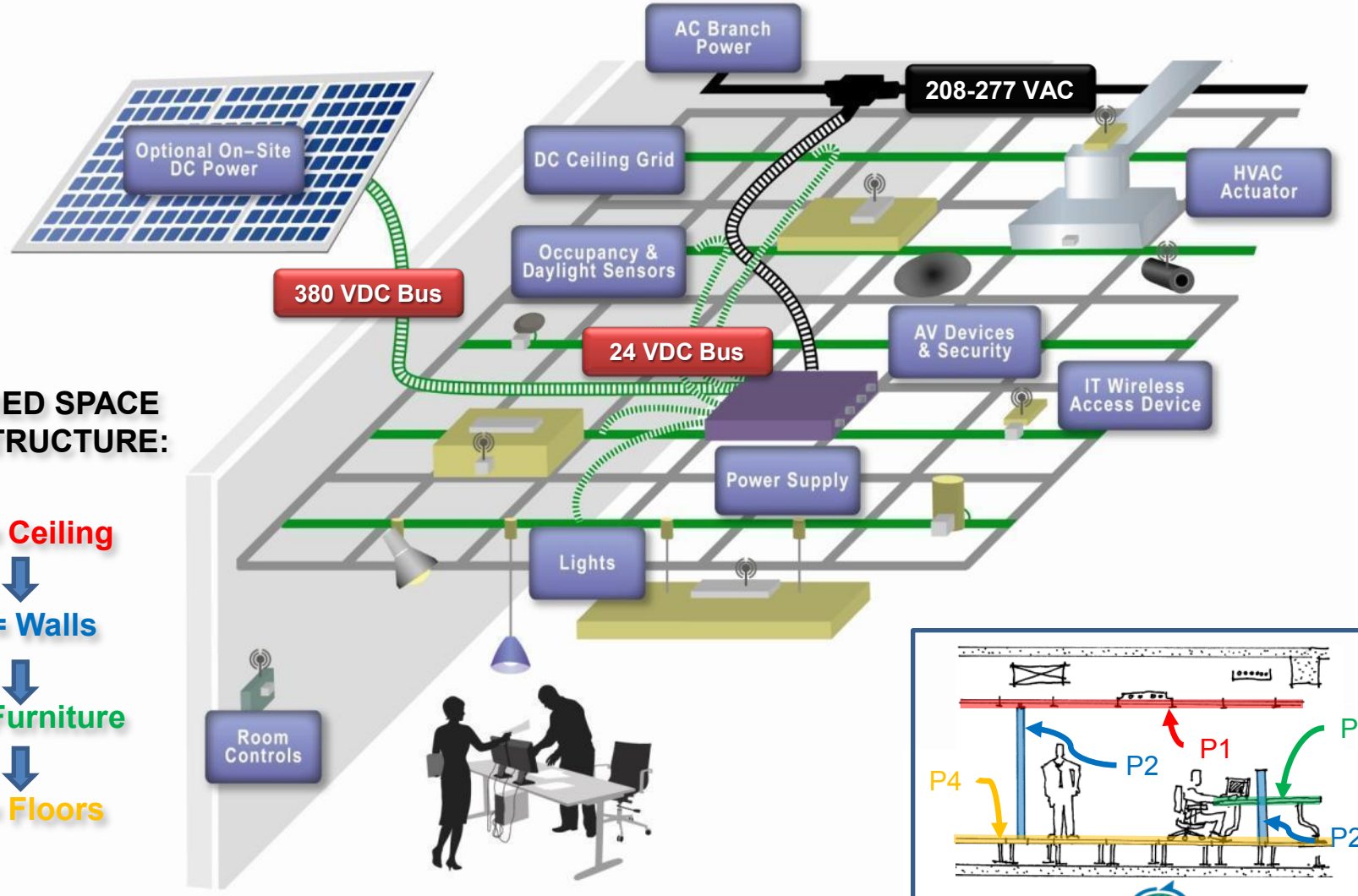
A Family of Open Power Standards for Hybrid DC Microgrids

EMerge ALLIANCE

1st Standard: Occupied Space

Developed for commercial interiors

Status: Version 1.0 Issued, Version 2.0 in Committee development



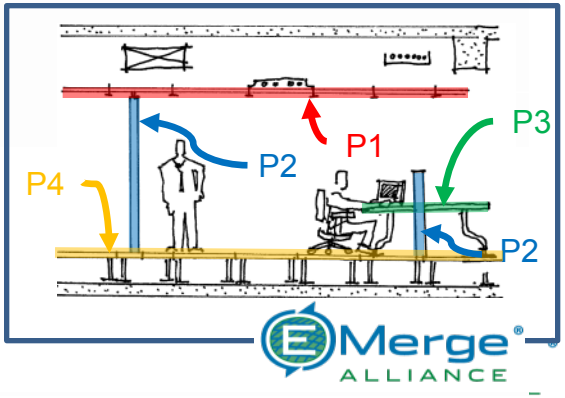
OCCUPIED SPACE INFRASTRUCTURE:

P1 = Ceiling

P2 = Walls

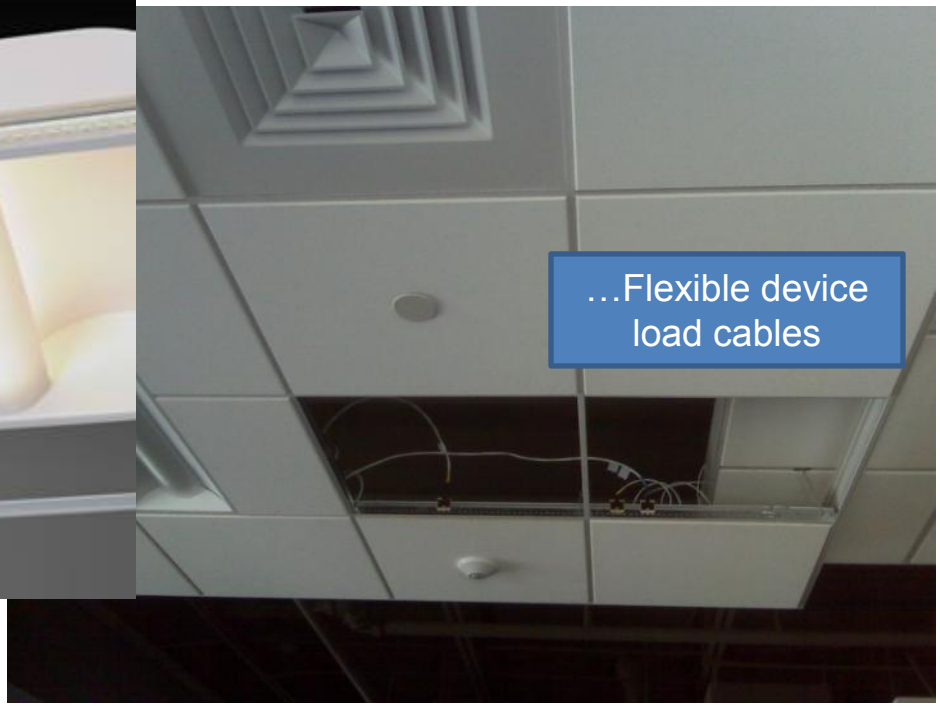
P3 = Furniture

P4 = Floors



Product Example: Fluorescent Fixtures

Current Designed & Listed Product → **Change to DC Ballast** → **Add Device Load Connector/Cable Assembly**



Slide Courtesy of Armstrong World Industries

- Direct DC input eliminates AC-DC conversion
- Can improve ballast efficiency by 10% or more
- Results in higher lighting system efficacy (light output per watt)
- Can improve ballast reliability significantly by eliminating HV inductors

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Product Example: LED Fixtures

Current Designed & Listed Product → **Change to Listed DC Driver** → **Add Listed Device Load Connector/Cable Assembly**

Slide Courtesy of Armstrong World Industries

- Direct DC input eliminates AC-DC conversion
- Can improve driver efficiency by 10% or more
- Results in higher lighting system efficacy (light output per watt)
- Can improve driver reliability significantly by eliminating HV inductors

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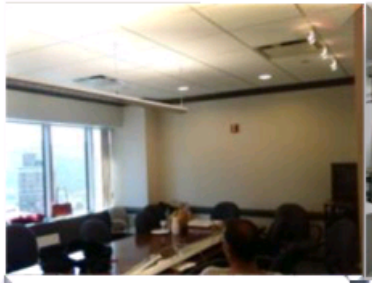
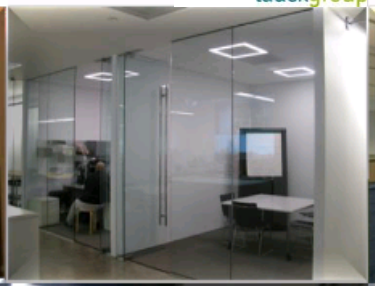
EMerge Alliance Occupied Space Standard

Example Site Applications in the Field

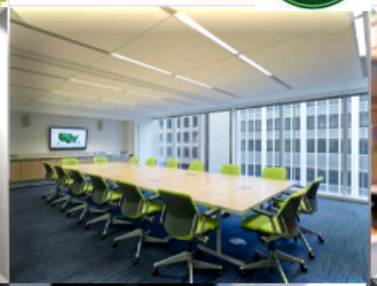
PNC Financial
Headquarters Office
Pittsburgh, PA



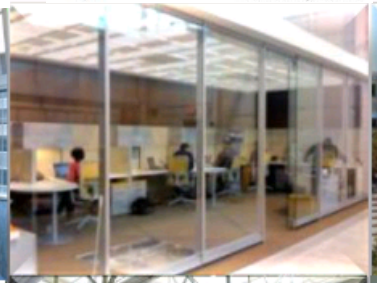
lauckgroup
Architectural Office
Dallas, TX



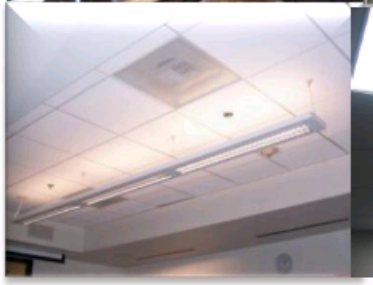
US Green Bldg Council
Conference Rooms
Washington, DC



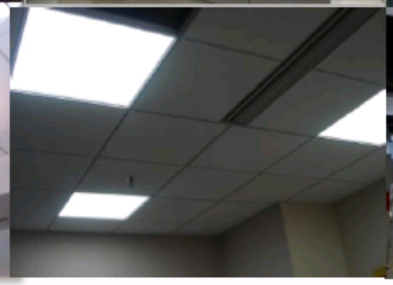
Nextek Power
NextEnergy Center
Detroit, MI



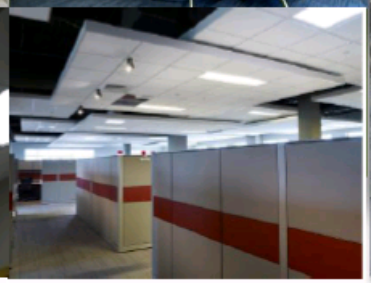
UC San Diego
Sustainability Center
San Diego, CA



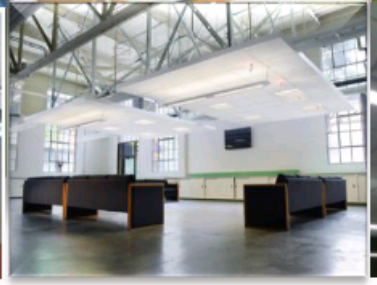
Southern Cal Edison
Utility Services Office
Irwindale, CA



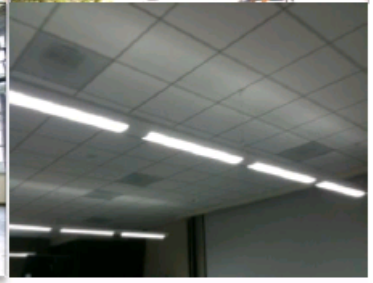
Johnson Controls
Headquarters Office
Milwaukee, WI



Optima Engineering
MEP Firm
Charlotte, NC



LA Community College
Trade Tech Campus
Los Angeles, CA



CA Lighting Tech Center
UC Davis Campus
Davis, CA

EMerge Alliance Occupied Space Standard

Example of Net Zero Energy Building

PNC

PNC Financial Services Group Inc. announced it will debut its new net-zero energy bank branch during first quarter 2013 in Fort Lauderdale, Fla.

PNC expects the branch to exceed LEED Platinum certification and be its most energy efficient, using 50 percent less energy than a typical branch.

The bank features solar connected **DC FLexZone™** ceilings that distribute native dc electricity to power efficient solid-state LED lighting and controls.

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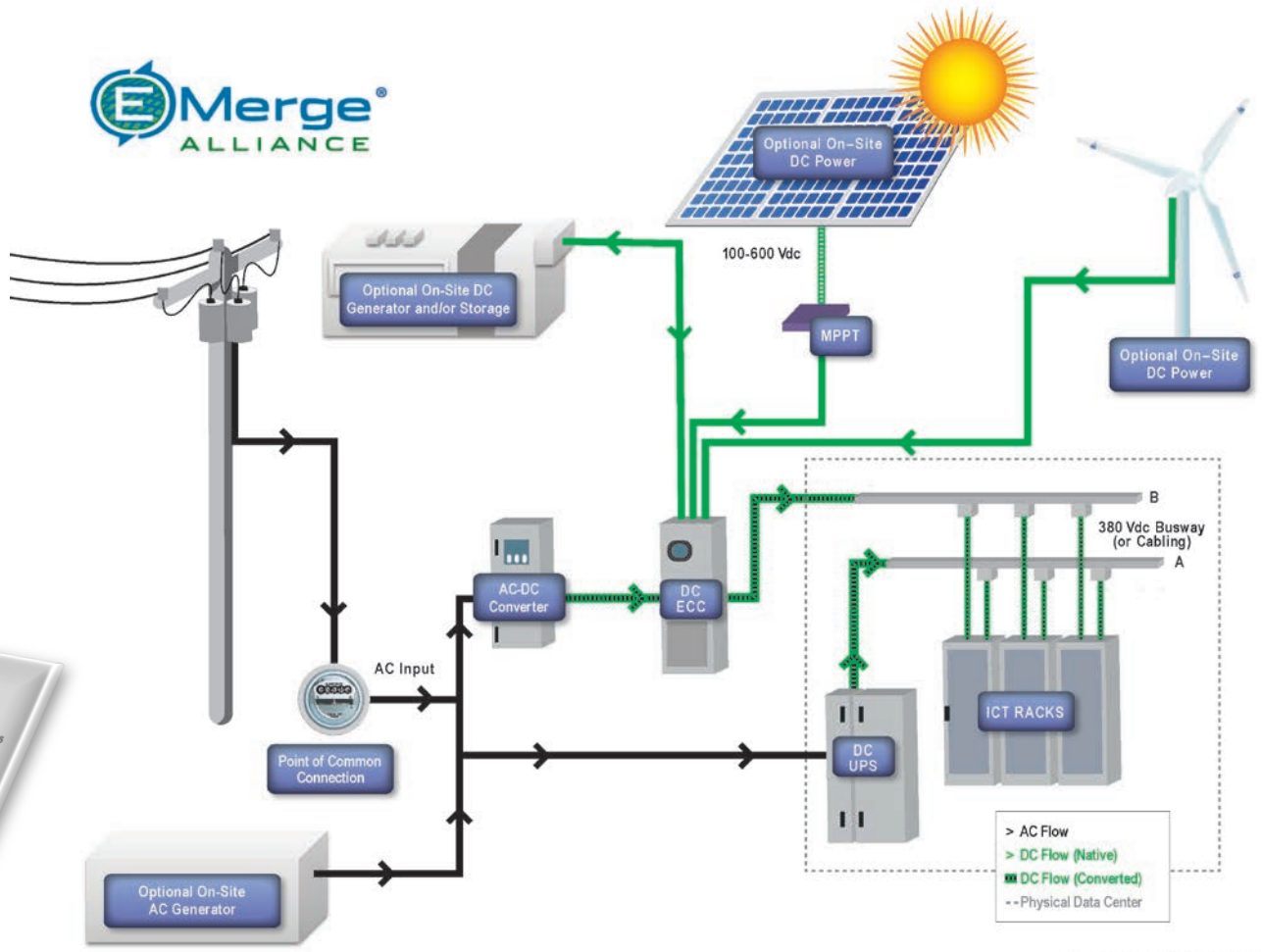
2nd Standard: Data and Teleco

Developed for 380VDC ICT System

Status: Complete - Pending Final Approval (October 2012 Release)



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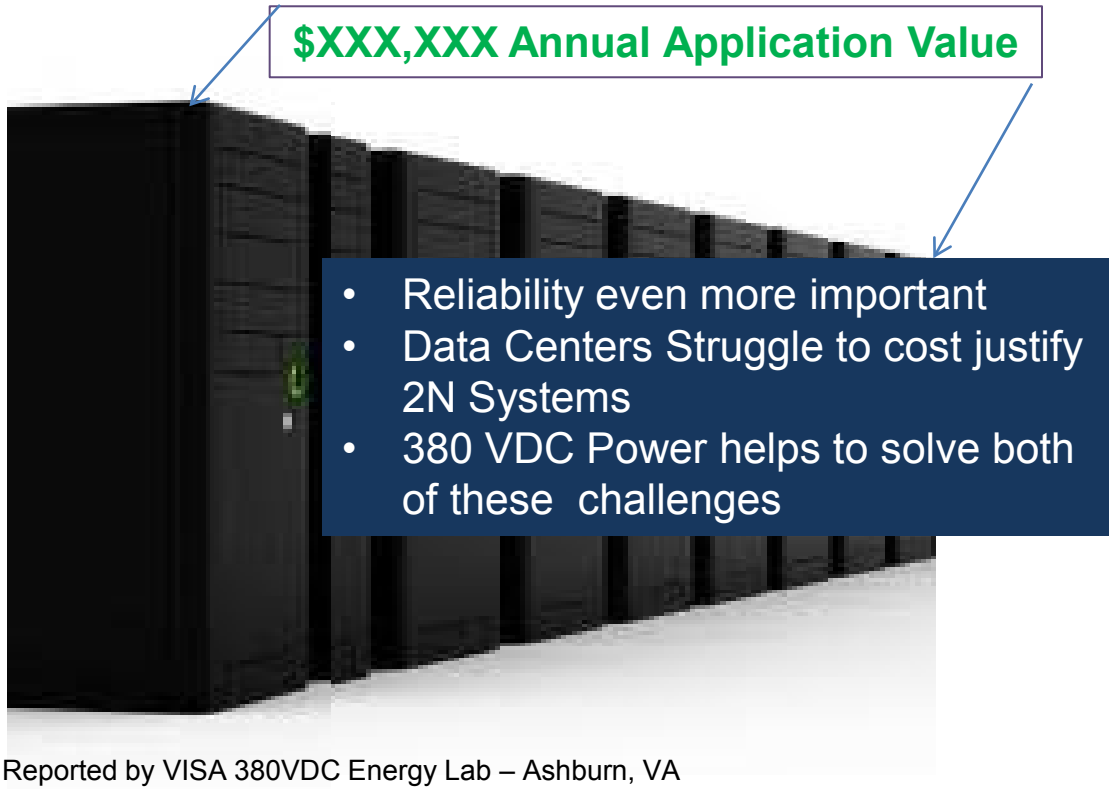
VISA: Virtualization…is driving power density



Reported by VISA 380VDC Energy Lab – Ashburn, VA

***Average consolidation is 8:1**

Average Maintenance Agreement for 1U Server is $500
Average Maintenance Agreement for 2U Server is $750
8:1 Consolidation yields $3250 of savings per year

***Power Consumption**

Average current 1U power supply is 675W
Average current 2U power supply also 675W
8:1 Consolidation yields a savings of 4725 Watts
4 tons of CO_2 are eliminated for every server virtualized, the equivalent to taking 1.5 cars off the highway.

***Application Value Density**

8 racks into 1 = 8 Racks of Value in 1

EMerge Alliance Data/Telecom Standard

Applications in the Field

EPRI/LBNL - Electric Power Research Institute
Lawrence Berkeley National Lab, California

Ernest Orlando Lawrence Berkeley National Laboratory

EPRI | Electric Power Research Institute

Duke Energy data center in Charlotte, North Carolina

Duke Energy

Calit2 - California Institute for Telecommunications and Information Technology , UC San Diego

Sustainability Resource Center
Equity-Environment-Economy
UC San Diego
Local Impact, National Influence, Global Reach

it²

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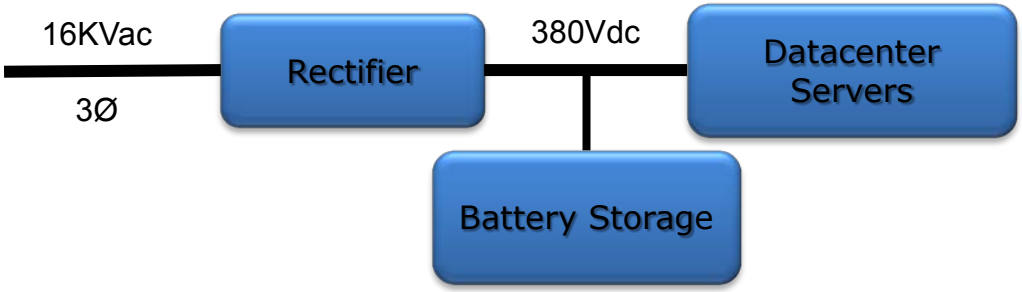
EMerge Alliance Data/Telecom Standard

Applications in the Field

green.ch - ABB
The Internet Company

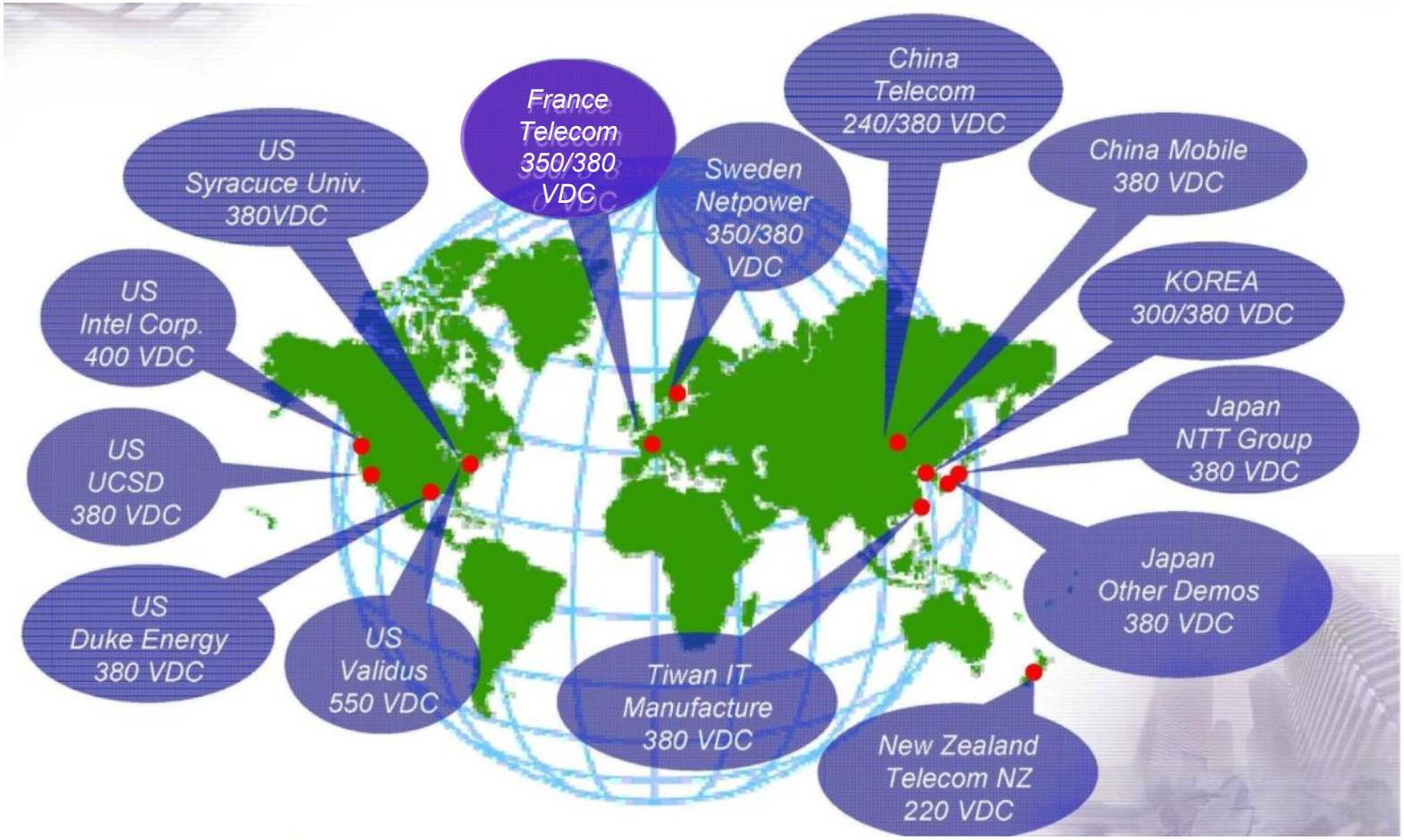
Zurich-West 380Vdc Data Center

- ABB/Validus Power Distribution
  - In: 16KV AC
  - Out: 1MW @ 380Vdc
  - Battery Backup: 10 mins
  - Backup Generation
- 1,100m^2 of 3,300m^2 Vdc
- HP 2U, Blades & Storage Servers
- Demonstrated Benefits
  - 10% Better Energy Efficiency
  - 15% Lower Capital Cost
  - 25% Smaller Footprint
  - 20% Lower Installation Costs



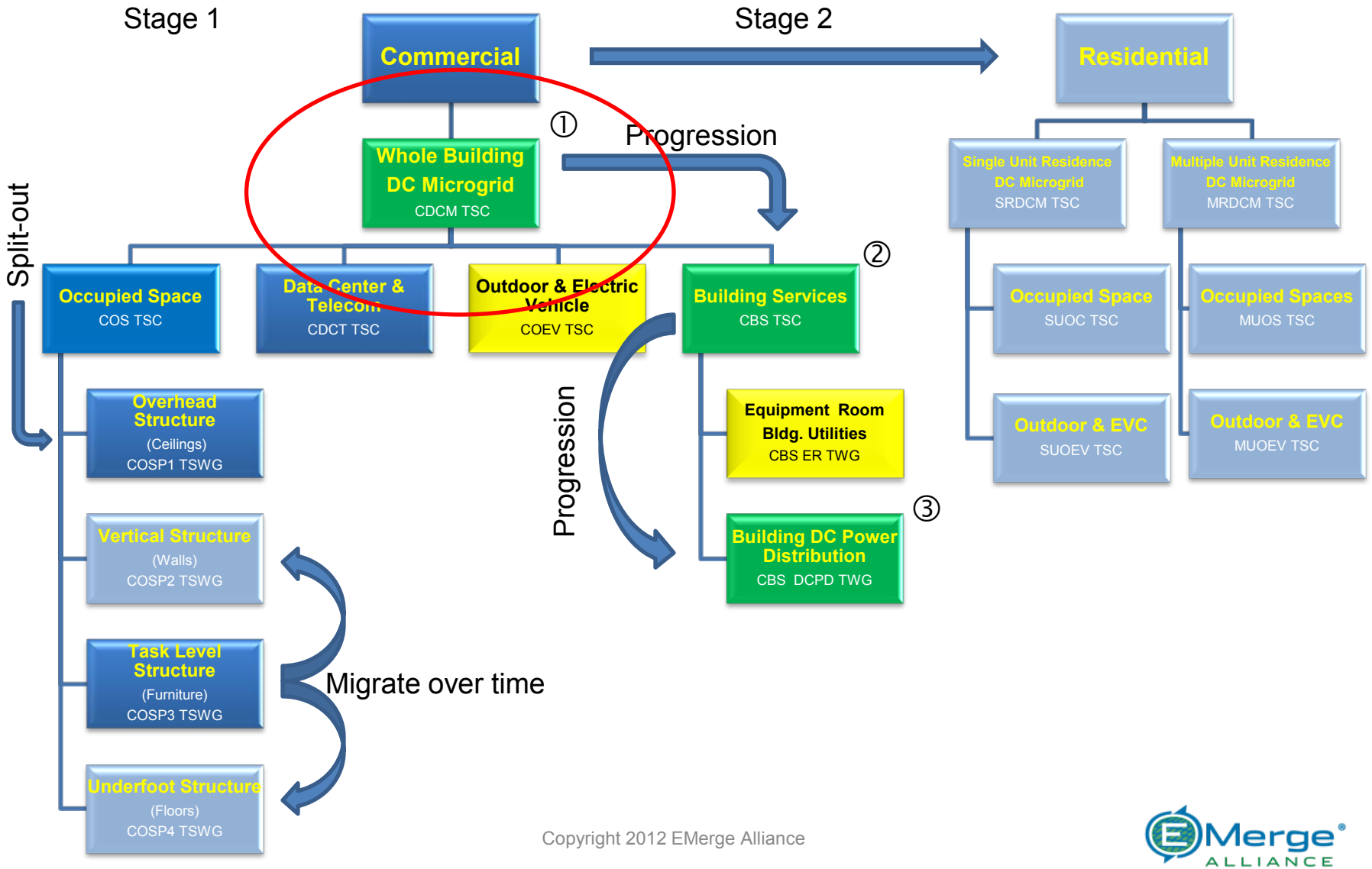
Photos courtesy of Green-ch, ABB* and HP*

OVER 200 DC SITES AROUND THE WORLD



Courtesy of Electric Power Research Institute

Application Standards Committee Roadmap



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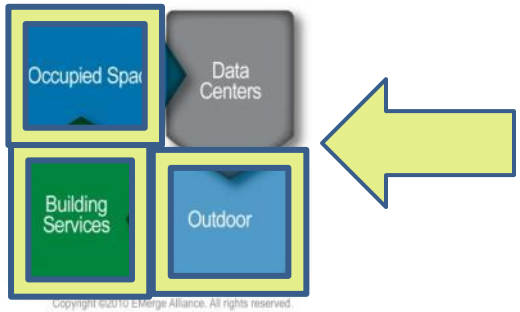
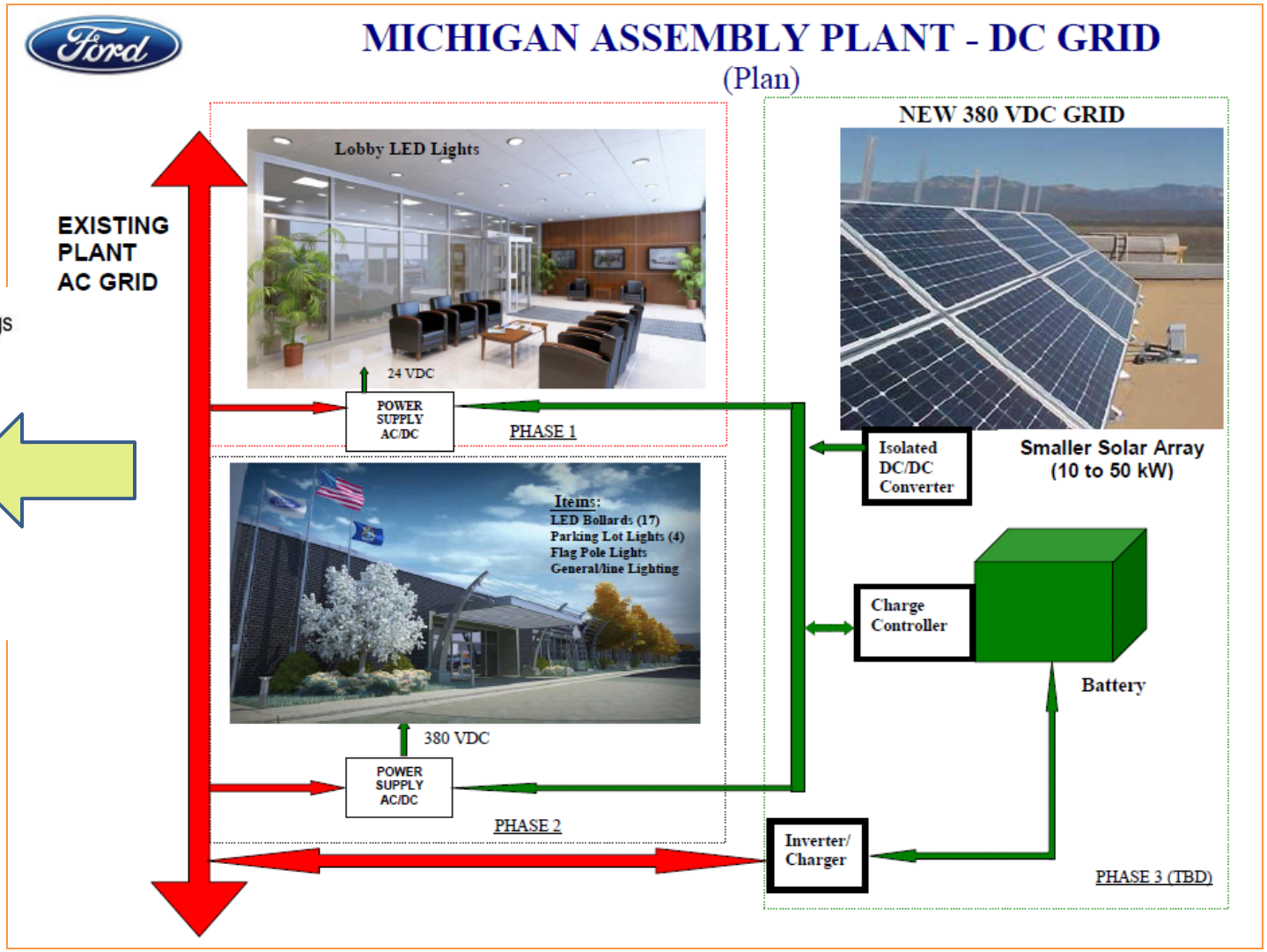
Whole Building Hybrid DC Microgrid

Ford's Deep Renovation Strategy Includes Multiple Stages

Vision: DC Microgrids Throughout Buildings





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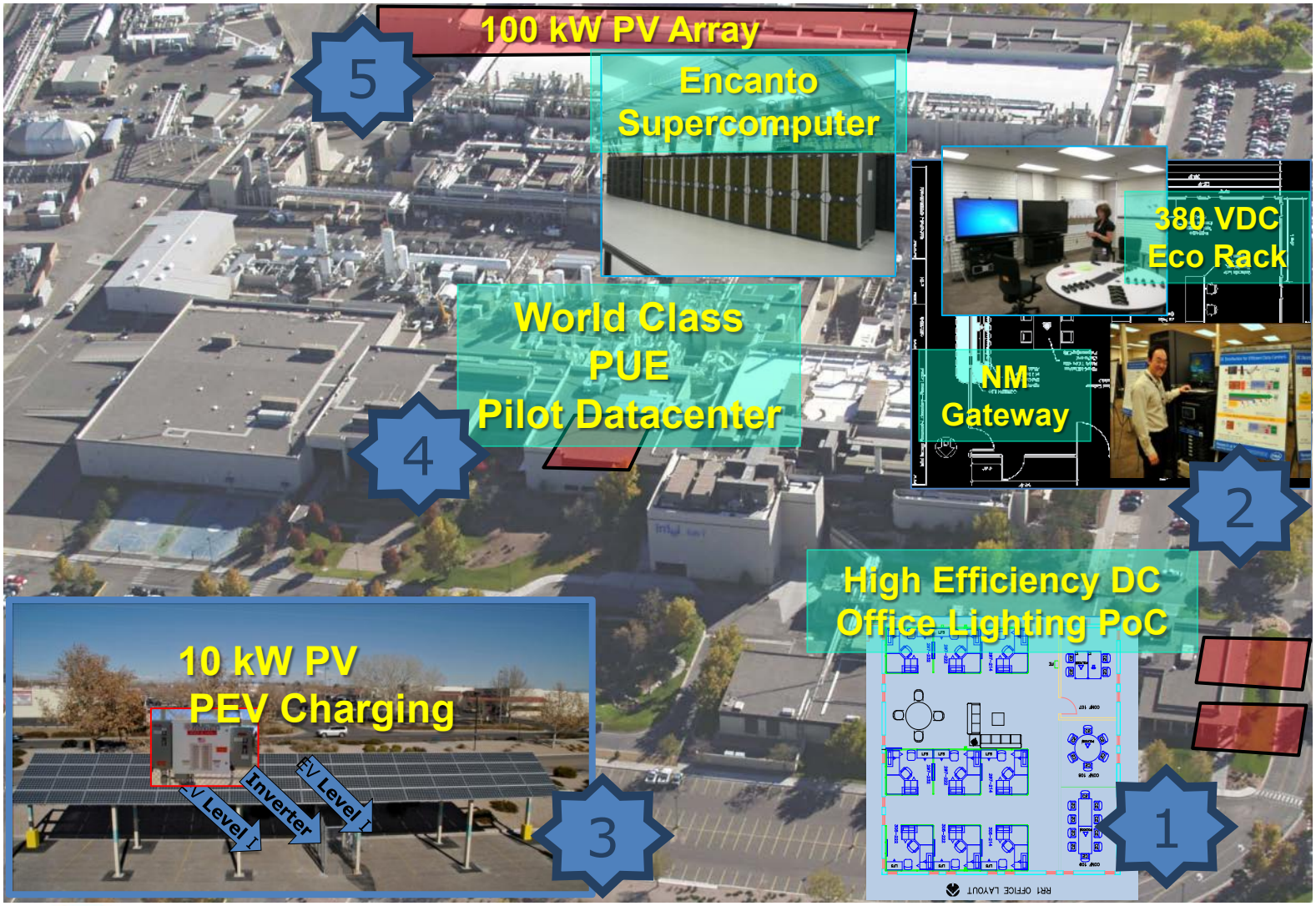
Standards Allow Incremental Plan/Execution

Five Discrete Projects Capture Key Elements

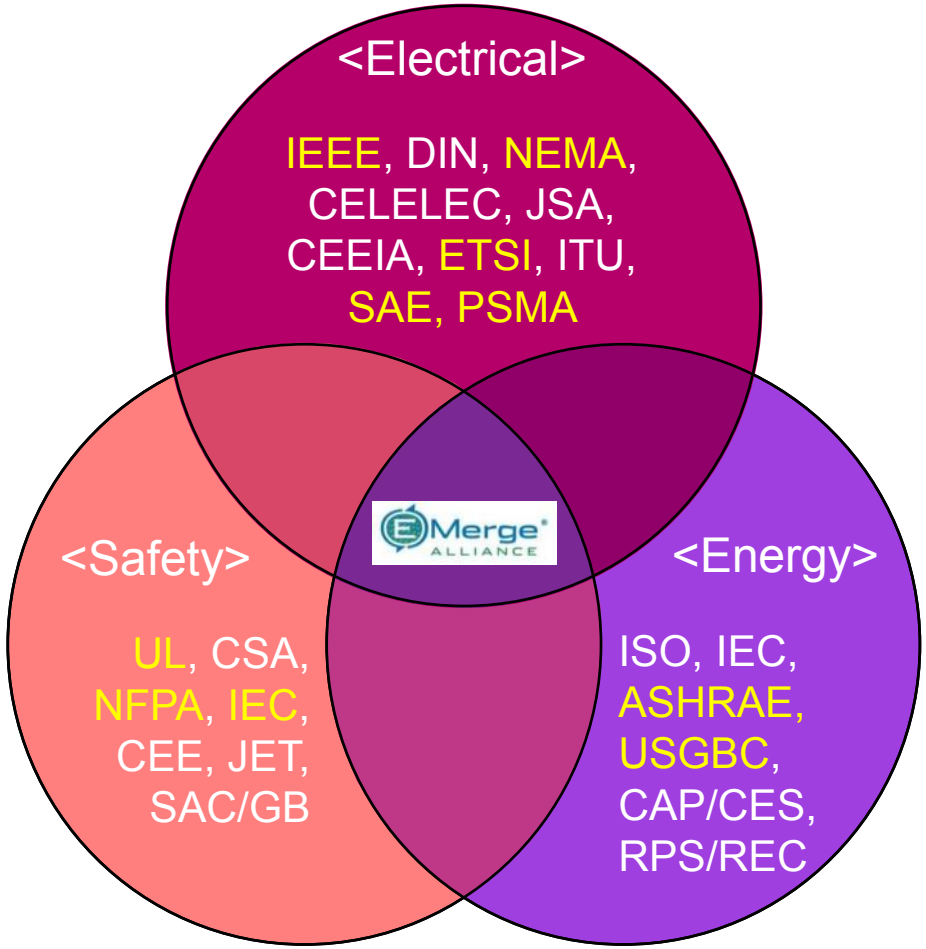


Rio Rancho Campus

Courtesy of Intel Research Labs

Information/Collaboration/Harmonization

Formal and Informal Inter-organizational Relationships

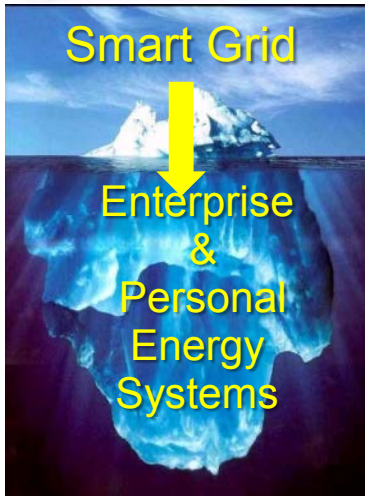


Standards Coming Up in…

Task Level (desktop & plug loads)
Whole Building Microgrids
Outdoor DC / Electric Vehicle Charging
Building Services (HVAC)

DC - The Power to Change the World

- **Biggest transformation since the PC, Internet & Cell Phone**
  - Electric grid is transforming
  - Government regulation, incentives
  - Imperative to “save the planet”
  - New devices and sources predominantly dc
- **Opportunities - Goals**
  - EMerge Alliance as a catalyst
  - Focus on the Edge and work toward the middle
  - *Microgrids – make DC and AC both a big part of the solution set*
  - Accelerate the transition – pull 2030 into this decade
  - Resource 1.5B people without power world-wide



Enernet: DOING FOR POWER WHAT THE INTERNET DID FOR INFORMATION NETWORKING

THANK YOU!

Thanks to the following organizations who helped make this presentation possible…

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